



Evaluation of a 40-Inch Muskellunge Length Limit at Berlin Reservoir*

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Abstract. A 40-inch muskellunge *Esox masquinongy* length limit at Berlin Reservoir failed to achieve the management objective of producing a self-sustaining stock of at least 1 adult muskellunge per 5 acres by 1996. Emigration and spring water levels influenced muskellunge population density, but angler harvest did not because anglers caught few muskellunge and released most of their catch. In some years emigration resulted in greater losses of muskellunge from the reservoir than did angler harvest. Year class success appeared related to spring water levels because strong year classes followed high water levels during April and May, whereas weak year classes followed low water levels during these months. Continuation of the 40-inch muskellunge length limit was not justified biologically.

Muskellunge *Esox masquinongy* are indigenous to Ohio and have been managed since the 1870's through stocking, fishing regulations, habitat manipulation, and angler access development. Ohio muskellunge fisheries have been regulated with a statewide daily bag limit of two fish and no length limits, and the same bag limit plus 30-inch minimum length limits at Pymatuning Lake and the Ohio River which are jointly managed through reciprocal regulations with the adjacent states.

Self-sustaining muskellunge fisheries are usually managed with minimum length limits, bag limits, and closed seasons (Miller 1983). Minimum length limits ranging from 26 inches to 36 inches are often imposed to protect immature fish, permit fish to spawn at least once, promote a trophy fishery, and reduce exploitation. Length limits were increased from 36 inches to 44 inches in the St. Lawrence River (1987) and Niagara River (1995), New York for these reasons (personal communication Steve Lapan, New York Department of Environmental Conservation). Similar reasons were cited for establishing 40-inch length limits on eight separate waters in the Province of Ontario during 1990. These waters include Lake St. Clair, the St. Lawrence River, Lake St. Francis, Eagle Lake, Lake-of-the-Woods, Lake Superior, Lake Erie, and Lake Ontario (personal communication John Tilt, Ontario Ministry of Natural Resources). The Ontario length limit was increased to 44 inches in the St. Lawrence River during 1991 to agree with New York regulations. Evaluations are not planned for these trophy length limits.

Evaluations of muskellunge management have focused on stocking practices. Whereas length limits have become a common tool for managing muskellunge, few of these regulations have been evaluated due to the difficulties of studying this species which result from its limited distribution and typically

low population densities (Dombeck 1981). Following a minimum length limit increase from 30 inches to 34 inches at Bone Lake, Wisconsin during 1982-1985, Cornelius (1987) found that the number of 30 to 36-inch fish increased 100 percent, while the number of muskellunge greater than 36 inches decreased 29 percent. Exploitation of 36-inch and greater fish increased by 51 percent during the study period in response to increased fishing pressure and harvest.

Berlin Reservoir is the only Ohio impoundment where a sport fishery for muskellunge has developed from natural reproduction. Angler catches of muskellunge at this reservoir peaked in the mid-1980's and began to decline thereafter, leading to speculation by anglers and biologists that angling mortality of potential brood stock may have been excessive. A 40-inch minimum length limit and this evaluation were initiated in 1991 to address these concerns. The objective of the evaluation was to determine if a 40-inch minimum length limit on muskellunge would produce a self-sustaining stock of at least 1 fish per 5 acres that are at least age 4 within 5 years. The management goal was to improve the stability of the muskellunge population at Berlin Reservoir and possibly address overharvest issues as identified in the Muskellunge chapter of Ohio's Fish and Wildlife Strategic Plans 1990-1995 and 1995-2000.

Study Site

Berlin Reservoir is a 3,650 acre impoundment located on the Mahoning River in northeastern Ohio. The impoundment was created in 1942 by the United States Army Corps of Engineers for the purpose of flood control and industrial water supply. Maximum depth is 62 feet, mean depth at

summer pool is 16.5 feet, and annual pool fluctuation is 20 feet. Lake substrate is primarily sand and rock rubble above 1,009 feet elevation and sediment below this elevation. Submerged vegetation is rare, but common cattail *Typha Latifolia* and black willow *Salix nigra* are abundant and often flooded during spring. The sport fishery is composed of walleye *Stizostedion vitreum*, largemouth bass *Micropterus salmoides*, smallmouth bass *Micropterus dolomieu*, white crappie *Pomoxis annularis*, black crappie *Pomoxis nigromaculatus*, muskellunge *Esox masquinongy*, channel catfish *Ictalurus punctatus*, white bass *Morone chrysops*, and bluegill *Lepomis macrochirus*. The dominant prey fish is gizzard shad *Dorosoma cepedianum*.

Muskellunge were absent from the Mahoning River (pre-impoundment Berlin Reservoir) prior to annual stockings of fingerlings upstream at Deer Creek Reservoir during the period 1956-1972. Berlin Reservoir has never been stocked with muskellunge, therefore the current population was established from these upstream stockings. Angler reports of muskellunge declined and ceased at Deer Creek Reservoir by 1989 but continued and increased at Berlin Reservoir. Two age 0 muskellunge were captured by the Division of Wildlife at Berlin Reservoir during routine surveys in 1979, although no muskellunge were stocked in the entire watershed that year (LaConte 1981).

Age determinations from scales collected by anglers and Division of Wildlife sampling crews were used to document the reproduction of muskellunge within the reservoir during most years after stockings had been discontinued. LaConte (1981) found that of 50 scale samples submitted by anglers, 92% were determined to have been from fish spawned during years when muskellunge were not stocked. Berlin Reservoir is the only impoundment in Ohio that has established a self-sustaining

muskellunge sport fishery. Voluntary angler reports (Ohio Huskie Muskie Club) annually averaged 4 fish from 1972 through 1980, 48 fish from 1981 through 1987, and 11 fish from 1988 through 1990.

Methods

Population, age, instantaneous total mortality, angling mortality, and emigration were determined from annual trap net and electrofishing surveys. Population data were collected with trap nets during March and April each year. Six fourteen-foot trap nets were placed in Berlin Reservoir each spring. All muskellunge were measured to the nearest inch and sex was determined. These fish were tagged with Floy dart tags and fin-clipped prior to mid-lake release to estimate minimum exploitation, population density, and emigration. Population estimates were calculated after each day of netting using the modified Schnabel method (Ricker 1975). Fin-clipping was used to determine the extent of tag loss. Scales were removed from all muskellunge captured to determine the age composition of the population. The decreasing percentage of muskellunge in the trap net catch was used to calculate instantaneous total mortality (Ricker 1975). A one day electrofishing survey was conducted each June in the two mile section of tailwater downstream of Berlin Reservoir to assess emigration.

The sport fishery was assessed with creel surveys conducted during 1991 and 1993 to estimate catch, effort, and success rates of muskellunge anglers. Additional sport fishing data were obtained from voluntary reports via a cooperating sport fishing group (Ohio Huskie Muskie Club).

Length limit signs were posted at all public fishing access points to inform the fishing public about the experimental length limit. Local concessionaires were informed about implementation of the length limit. Division of Wildlife personnel also attended meetings of the local and statewide fishing clubs to inform them about the experimental length limit.

Daily water level data were obtained from the United States Army Corps of Engineers, Pittsburgh District.

Results

Population Characteristics

Forty-one muskellunge were captured in 1991, 40 in 1993, 14 in 1994, 11 in 1995, and 28 in 1996. Muskellunge catch per unit of effort (CPE) from trap nets was low but consistent at 0.01 fish per hour. Low water levels impaired netting during 1992, and low CPE in 1994, 1995, and 1996 precluded calculation of some population statistics. Total population estimates of adult muskellunge (age 4 and greater) were 32 ± 26 fish in 1991 and 84 ± 43 fish in 1993. Due to low adult muskellunge catches and missing year classes instantaneous total mortality calculations based upon catch curve regression were possible in only one year, 1991. Annual mortality was 26.0 % during 1991. Exploitation from tag returns ranged from 0 % (1993-1995) to 2.4 % (1991) annually.

Year class composition of the net catch changed dramatically during the six years of the study (Figure 1). The 1982 through 1989 year classes were represented in the 1991 net catch, but the 1990 and 1991 year classes were missing in the 1993 net catch. Sampling in 1994 indicated that the 1990, 1991, and 1992 year classes were missing and the 1988 - 82 year classes were dying out. During 1995, capture of seven fish from the 1993 year class provided the first signs of successful reproduction in three years. By 1996 net captures revealed that the fishery was composed primarily of the 1989 and 1993 year classes. One age 2 juvenile muskellunge was captured in 1996, but the success of the 1995 year class cannot be determined until 1998 when recruitment to the trap nets is complete. Female muskellunge at Berlin Reservoir become sexually mature at age 4 and reach 40-inches at age 6, whereas male muskellunge became sexually mature at age 3. Large male muskellunge were uncommon and the oldest and largest of 37 males was age 7 and 40 inches.

June electrofishing surveys in the Berlin Reservoir tailwater and tag returns from anglers who caught muskellunge in the Mahoning River and Lake Milton indicated emigration from the reservoir. Only one tagged muskellunge, a 34 inch fish tagged on April 25, 1996, was found during the 1991-1996 electrofishing surveys. This fish was captured on June 20, 1996 in the Mahoning River approximately 3 miles from Berlin Reservoir. All of the angler-caught muskellunge were caught at least one year after tagging. Three fish tagged in 1991 and 3 fish tagged in 1993 were caught downstream of Berlin Reservoir, and tagged fish as large as 44 inches were found in Lake Milton downstream of the Berlin Reservoir outflow structure. Tag returns suggest that emigration was at least 7.3 % in 1991, 7.5 % in 1993, and 4.3 % in 1996. By spring 1996, anglers had not reported catching fish tagged in 1994 or 1995 from the Berlin Reservoir tailwater or Lake Milton.

Sport Fishing Characteristics

Creel surveys were conducted at Berlin Reservoir from mid-April through mid-September during 1991 and 1993. Anglers fished $225,833 \pm 8144$ hours in 1991, but no muskellunge were observed or reported during the survey. In 1993, they fished $101,331 \pm 4687$ hours and caught an estimated 38 ± 36 muskellunge. Most of these fish (87 %) were released.

A review of voluntary angler records from the Ohio Huskie Muskie Club indicated that anglers caught muskellunge in Berlin Reservoir each year during 1991-1995. These anglers reported catching 3 (1991), 45 (1992), 21 (1993), 5 (1994), and 5 (1995) muskellunge over this period and harvested less than 10% of their catch (Ohio Department of Natural Resources 1991-95).

Water Levels

Daily spring water elevations were obtained from the United States Army Corps of Engineers for the period March 1 through May 31, 1989-1993. The United States Army Corp of Engineers schedule provides for spring water level increases to begin on April 1 each year. The summer pool elevation of 1,024.7 feet is scheduled to be attained on May 1 each year. Spring water levels during 1990, 1991, and 1992 were below scheduled elevations (Figure 2), whereas they were at or above scheduled elevations during 1989 and 1993.

Discussion

The muskellunge population at Berlin Reservoir was limited by low reproductive success and

emigration, but not angler harvest. Therefore, the 40-inch minimum length limit on Berlin Reservoir muskellunge did not meet the objective of increasing the population density to one adult fish per 5 acres. Although sampling difficulties hampered this evaluation, these data suggest that the major impediments to improving and stabilizing the population are variable water levels during April that may limit reproduction and high volume discharges during the late summer that exacerbate emigration.

Muskellunge harvest at Berlin Reservoir was unlikely to cause substantive mortality of any size of fish. This was not entirely due to the regulated length limit. Ohio muskellunge anglers release more than 90% of their catch, and statewide voluntary release rates for fish under 42 inches were 91.5% during 1991 through 1995 (Ohio Department of Natural Resources 1991-95). Creel surveys conducted in 1994 at two northeastern Ohio muskellunge lakes without length limits found voluntary muskellunge release rates of 90.0% (West Branch Reservoir) and 93.1% (Lake Milton). Therefore, the length limit on Berlin Reservoir muskellunge was unlikely to increase population density or survival to spawning age.

Natural mortality and emigration were the major causes of muskellunge losses from Berlin Reservoir. Annual reproductive success was the primary limiting factor in this fishery. Reproduction failed in 1990, 1991, and 1992 and new year classes did not replace older ones. The 1993 year class was the only significant year class since 1989. The length limit did not reduce angling mortality or improve population density.

Successful year classes were directly related to spring water levels. In 1989 and 1993, significant

year classes were produced when spring water levels reached the summer pool elevation of 1,024 feet prior to spawning in mid-April. When spring water levels did not reach elevation 1,024 feet by mid-April poor or weak year classes resulted. Water levels at or above elevation 1,024 feet flood hundreds of acres of emergent vegetation that provide excellent muskellunge spawning habitat. Water elevations below 1,024 feet offer only extensive shallow mud and sand flats to spawning fish, which is deficient spawning habitat (Dombeck 1986). Low numbers of muskellunge spawners appear to produce significant year classes when spawning conditions were favorable, whereas larger numbers of spawners did not produce offspring under poor conditions.

Each year muskellunge emigrate from Berlin Reservoir through reservoir discharge. Although annual emigration rates were less than 8%, they probably exceed angling mortality during most years. Emigration in 1991 was at least 7.3%, whereas angling mortality was at least 2.4 %, and emigration in 1993 was at least 7.5% with no reported angler harvest. Emigration may result in a substantial annual loss of fish from the reservoir, but losses did not appear rapid because only one fish was recovered downstream during the year it was tagged. This fish was recovered shortly after the unscheduled water releases of Spring 1996, but other recaptures downstream of Berlin Reservoir were recovered from one to three years post- tagging . Losses to emigration were probably greatest during July and August following massive water releases. These losses may be reduced by manipulating water levels and release schedules.

Management Implications

Water level management is a critical to maintain good year classes in the self-sustaining muskellunge fishery at Berlin Reservoir. High water levels should be attained and maintained during the spring spawning season in order to maximize potential for successful reproduction. Managing water levels is also important to reduce fish losses via emigration during the late season water releases. This situation and some proposed corrective measures have been discussed with the United States Army Corps of Engineers. The Division of Wildlife has suggested a revised annual water level manipulation schedule based upon an increase in winter pool elevation from the current 1,005 feet to 1,015 feet (Figure 3). An increased winter pool elevation to 1,015 feet would permit a more timely and efficient increase in spring water elevation to 1,024 feet by April 1 each year. Suitable spring water levels are more likely to be reached if less water is required to attain them. The higher pool elevation during winter months would also allow for reduced late summer water releases which may reduce emigration. The Corps of Engineers responded that they will work to cooperate with the Division of Wildlife within the constraints of their flood control mission.

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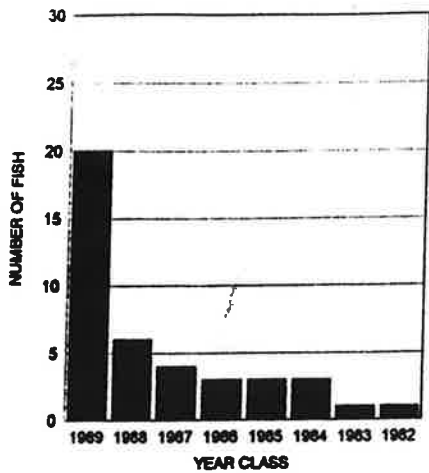
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List Of Figures

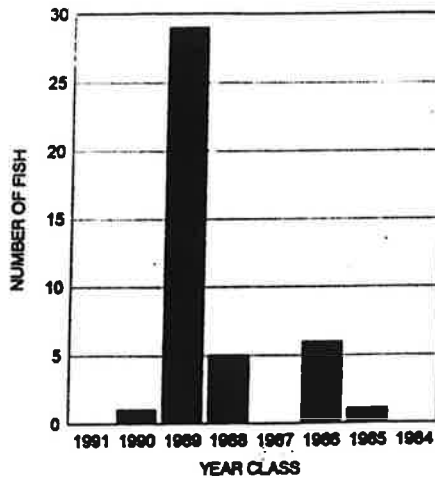
Figure 1. Year class composition of the net catch 1991-1996.

Figure 2. Berlin Reservoir spring water levels 1989-1993.

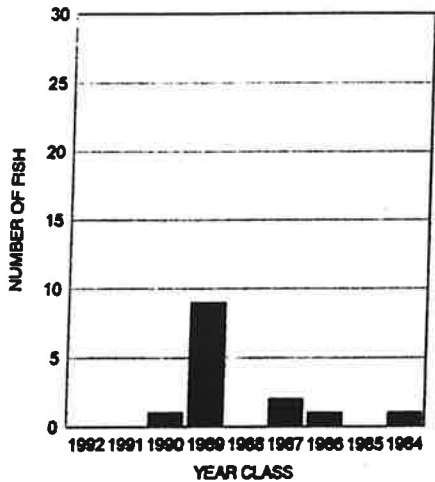
Figure 3. Proposed annual water schedule versus the existing schedule, Berlin Reservoir.



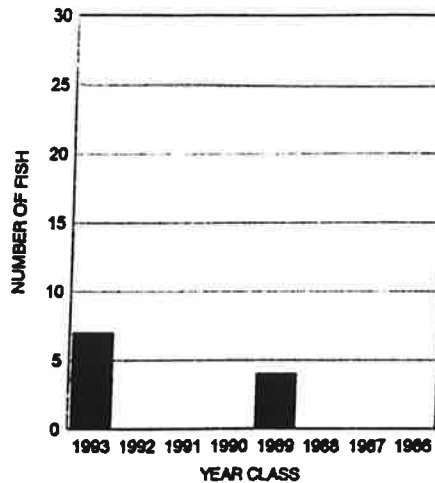
Muskellunge year class composition of the 1991 spring trap net catch, Berlin Reservoir.



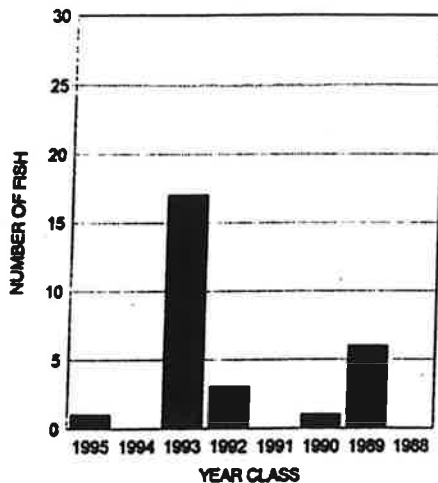
Muskellunge year class composition of the 1993 spring trap net catch, Berlin Reservoir.



Muskellunge year class composition of the 1994 spring trap net catch, Berlin Reservoir.



Muskellunge year class composition of the 1995 spring trap net catch, Berlin Reservoir.



Muskellunge year class composition in the 1996 spring trap net catch, Berlin Reservoir.

Figure 1. Year class composition of the net catch 1991-1996.

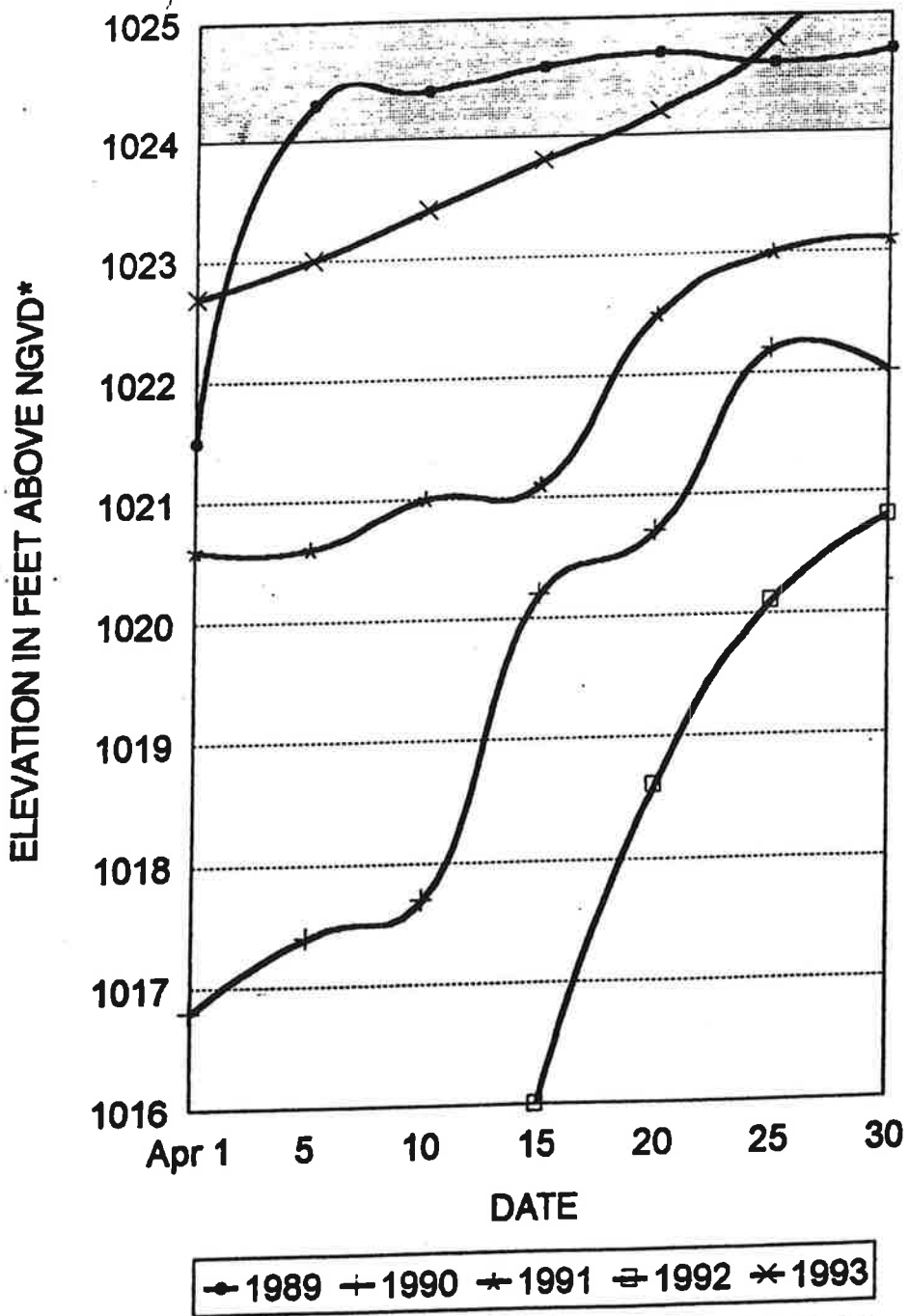


FIGURE 2. - Berlin Reservoir spring water levels 1989 - 1993.

*National Geodetic Vertical Datum (NGVD)

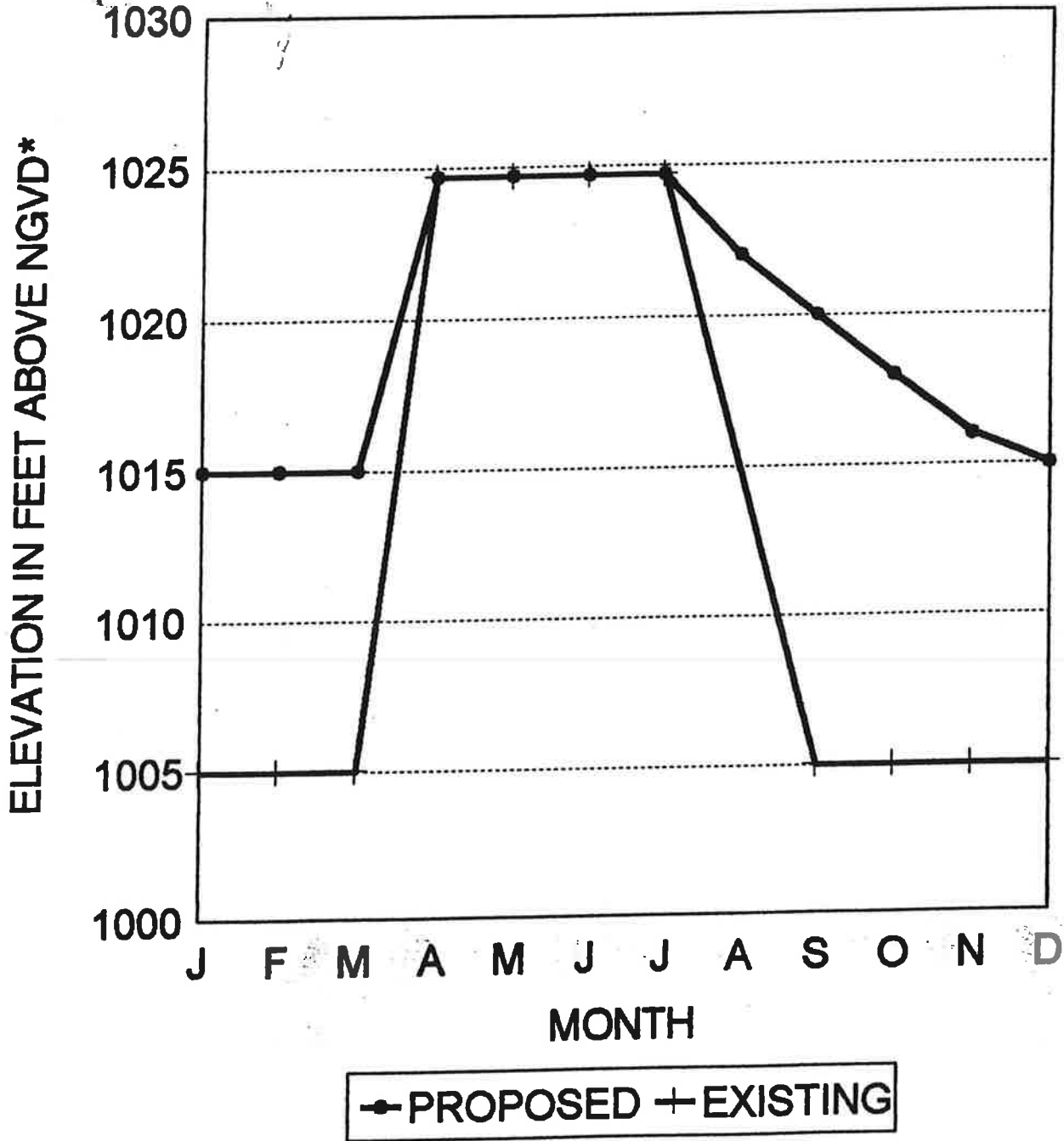


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